Review of Physiological Maladaptation

"Don't go there…without your PPE"

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Outline

- Acceleration
- Disorientation
- Hypoxia,T&E Gas
- Self-imposed Stress
  - Fatigue

ANTI-G STRAINING MANEUVER

PHASE 1

- Muscle Tensing
  - Legs
  - Stomach/Butt
  - Arms/Chest

PHASE 2

- Breathing Technique
  - 3 second cycles
  - Exhale w/closed glottis
  - Exhale/Inhale quickly

G-LOC Reasons for 15 F-16 Pilots

- Poor lower body strain - 8
- Poor breathing technique - 4
- Poor G awareness - 2
- Breath hold > 5 sec - 1
- Overpowering upper body strain - 1
- G suit not connected - 1

COMBAT EDGE

Combat Edge Dehydration Assessment

- Sep 98 - ACC/DO was asked to waive wear of the COMBAT EDGE vest on any single sortie in a given day
- Sep 99 - ACC/XO requested that AFRL conduct a study to compare the thermal load and dehydration effect of COMBAT EDGE and standard flight gear

Implications of Heat Stress

- During heat stress and increased heat production by physical exercise, the human body reacts with increased skin blood perfusion and sweating.
- Sweating causes increased evaporation on the skin, which cools down the skin and the blood at peripheral parts of the body.

Heat Stress... in Relation to G-LOC

- Dilation of skin blood vessels causes part of the blood volume to be directed to the body's superficial skin portions, leaving less blood in the central parts of the body.
- Results in less blood available for brain circulation during increased G-loads.
- Leads to decrease in G-tolerance and an increased risk of G-LOC.

Methods

- Subjects: 12 (6 aircrew and 6 centrifuge panel members)
  - Aircrew drawn from F-16, F-15C, and F-15E aircraft
- Assessments:
  - Thermal load
  - Dehydration
    - changes in body weight (total body water loss) and changes in Hb, Hct electrolytes, osmolality
  - Effect of dehydration/temperature on G tolerance

Methods (cont)

- Each subject completed two 4-hour tests separated by at least 44 hours
- Course of events: Centrifuge rides (baseline) - thermal exposure - repeat centrifuge rides
  - Thermal exposure: 30 minutes at 95 degrees and 85% humidity (20 minutes walking on treadmill at 2.5 mph)

Results

	COMBAT EDGE	STD GEAR
Mean of maximum core temperature	100.6 °F +/-0.7	100.6 °F +/-0.7
Mean of maximum temperature increase	1.6 °F +/-0.4	1.6 °F +/-0.5
Mean of maximum chest temperature	100.8 °F +/-1.4	100.4 °F +/-0.7
Mean weight loss	2.43 lbs	2.39 lbs
Mean percentage of body weight lost	1.3 %	1.3 %

FITS (Deg F) for Direct Sun

Air Temp (°F)	Zone	Relative Humidity (%)							
		≤ 10	20	30	40	50	60	70	≥ 80
70		67.1	69.6	71.9	74.4	76.7	78.6	80.6	82.6
75		71.3	74.1	76.8	79.3	81.7	84.0	86.2	88.2
80	Normal	75.4	78.6	81.4	84.2	86.9	89.3	91.6	93.8
85		79.3	82.9	86.1	89.2	92.0	94.7	97.1	99.5
90		83.4	87.4	90.9	94.2	97.3	100.2	102.8	105.4
95		87.5	91.8	95.8	99.3	102.5	105.6	108.4	111.0
100		91.4	96.2	100.3	104.3	107.8	111.2	114.0	116.8
105	Caution	95.5	100.3	105.1	109.3	113.1	116.4	119.5	122.4
110		99.3	104.9	110.0	114.4	118.4	121.9	125.1	128.2
115	Danger	103.2	109.4	114.7	119.5	123.6	127.2	130.5	133.6
120		107.3	113.9	119.4	124.5	128.8	132.6	136.1	139.5

F-22/COMBAT EDGE Integration

- Study requested by ACC to examine integration of F-22 aircraft mounted life support system (LSS) components with COMBAT EDGE and ATAGS
- Study involves acceleration, altitude, cockpit, and thermal evaluations
- F-22 Aircraft Components of LSS
  - On Board Oxygen Generating System (OBOGS)
  - Breathing Regulator Anti-G Valve (BRAG Valve)
  - Emergency Oxygen System (EOS)

F-22/COMBAT EDGE Integration

- Acceleration, cockpit, and thermal portions completed
- No major integration/performance problems found thus far
- F-22 cooling vest performance
  - Core temperatures exceeded recommended limits for both F-22 LSS and COMBAT EDGE
- Altitude trials to 60,000 feet
- ATAGS flight qualification tests in July ‘00 and operational test and evaluation in early Autumn ‘00

Color Vision Changes During High +Gz

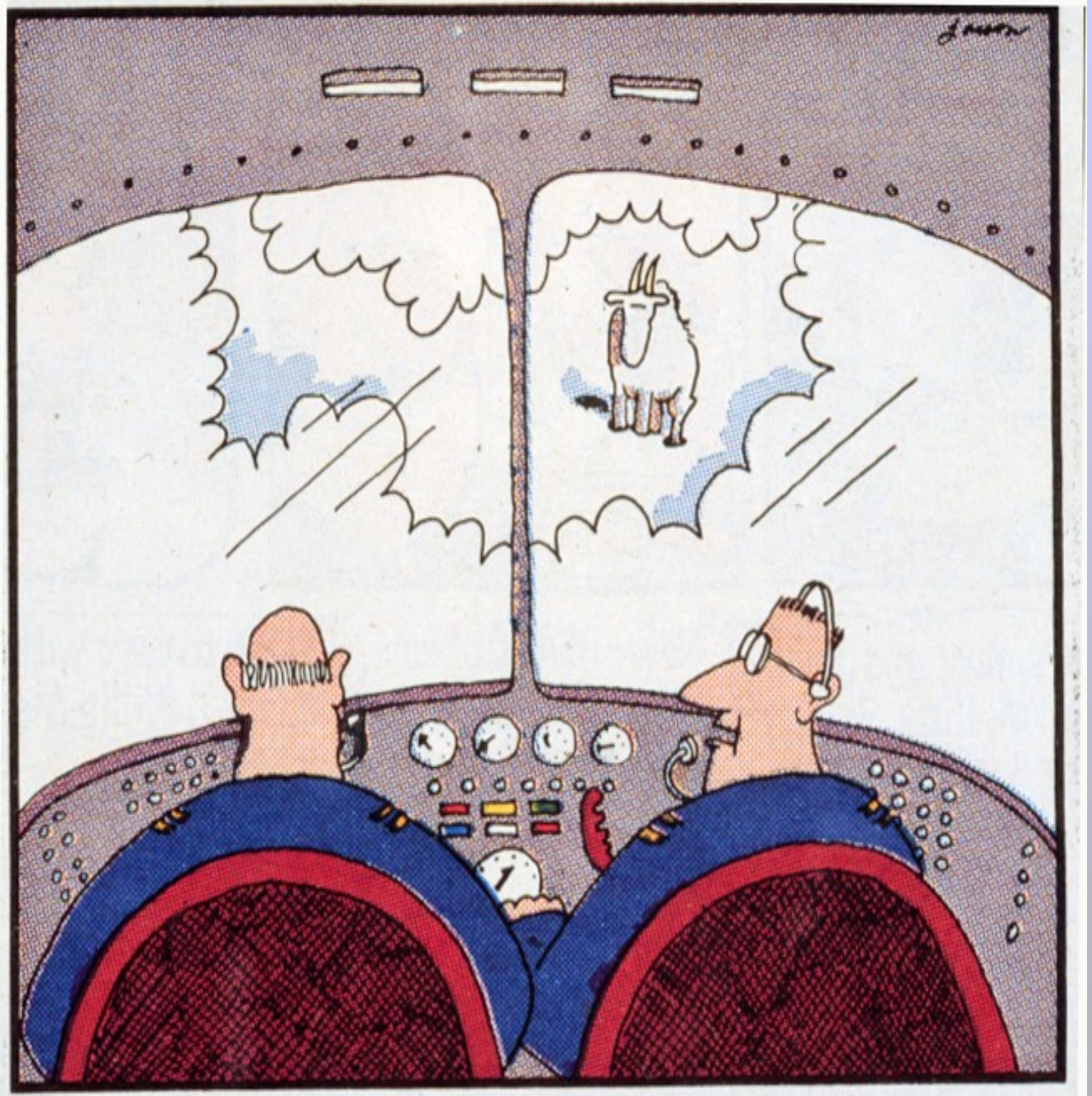
- Study investigated if color vision is affected by +Gz loads up to +9 Gz
- Examined changes in the perception of yellow, red, blue, green, and gray
- Data still being analyzed
- Changes in color perception have been noted
  - Example: green changing to yellow

Spatial Orientation Update

Spatial Disorientation Types

TYPE I -- *Unrecognized*

- **Pilot Does Not Consciously Perceive Any Manifestation of Spatial Disorientation**
- **Most Often Occurs When Pilot Breaks Cross-Check**
- **Most Likely to Lead to Controlled Flight Into Terrain**



"Say . . . What's a mountain goat doing way up here in a cloud bank?"

Spatial Disorientation Types

TYPE II -- *Recognized*

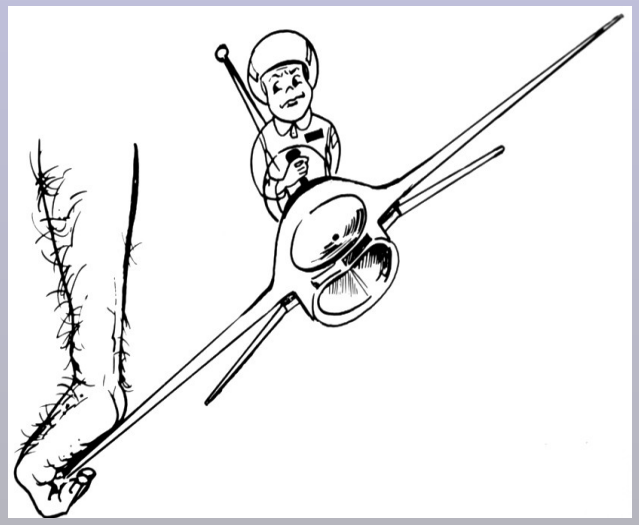
- **Pilot Consciously Perceives A Manifestation of Spatial Disorientation but not attribute it to SD itself**
- **Conflict between “Natural” and “Synthetic” SD Percepts May Occur**
- **Instrument Malfunction Is Often Suspected**

SO I'M A LOUSY INSTRUMENT PILOT! DON'T JUST SIT THERE!! CALL FOR A STRAIGHT IN APPROACH !!

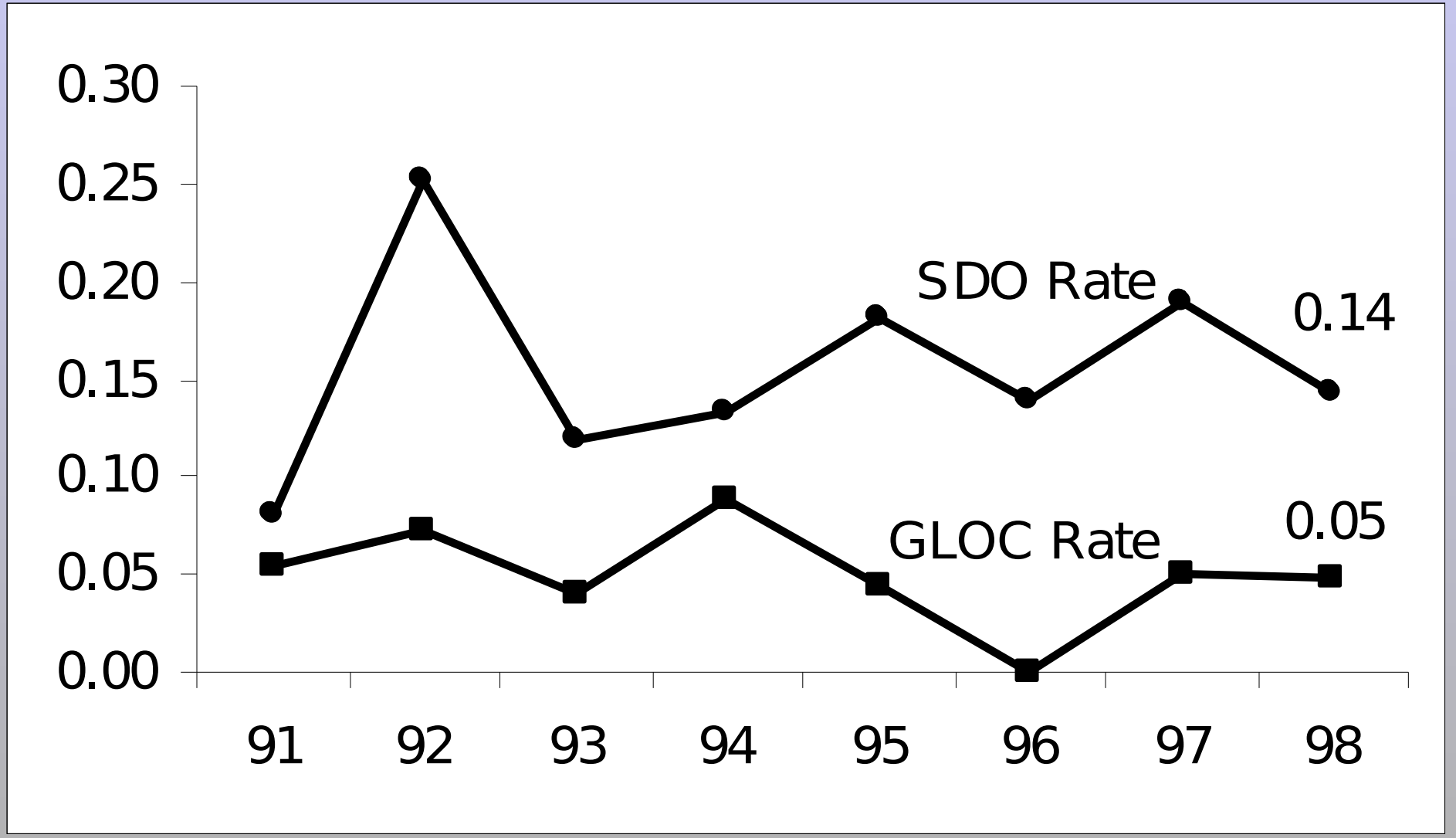
Spatial Disorientation Types

TYPE III -- *Incapacitating*

- **Experienced by 10-15% of aviators**
- **Vestibulo-Ocular Disorganization (i.e., uncontrollable nystagmus)**
- **Motor Conflict (e.g., “Giant Hand”)**
- **Temporal Distortion**



SDO v. GLOC Class A Rates/ 100,000 Hrs



FY ‘91-98
SDO v. GLOC

- SDO EVENTS: 58
- COST: $1,308,138,270.00
- FATALITIES: 50
- CONTRIBUTING FACTORS:
  - Attention Management
  - Judgment/Decision

- GLOC EVENTS: 11
- COST: $173,905,092.00
- FATALITIES: 8
- CONTRIBUTING FACTORS:
  - Attention Management
  - Pathophysiological

SDO

- Greater Number of Human Variables?
- Greater Exposure to the Threat?
- Harder to Train?
- Role of Contributing Factors?

SDO Training

- Traditional:
  - Biodynamic: Acceleration Forces
  - “Visual Dominance / Vestibular Suppression”
  - Supra v. Sub Threshold Events
  - Tended to be Focus of Training
- Demonstration:
  - Barany Chair/Vista Vertigon/ASDD?

U.S. AIR FORCE

Recovery From SDO

- Reestablish visual dominance (instrument cross-check)
- Make instruments read right
- Straight-and-level flight (autopilot, if available)
- Notify other crewmember or flight members (if applicable)
  - Verbally confirm flight parameters
- Consider route abort procedures
- Consider lost wingman procedures (if applicable)

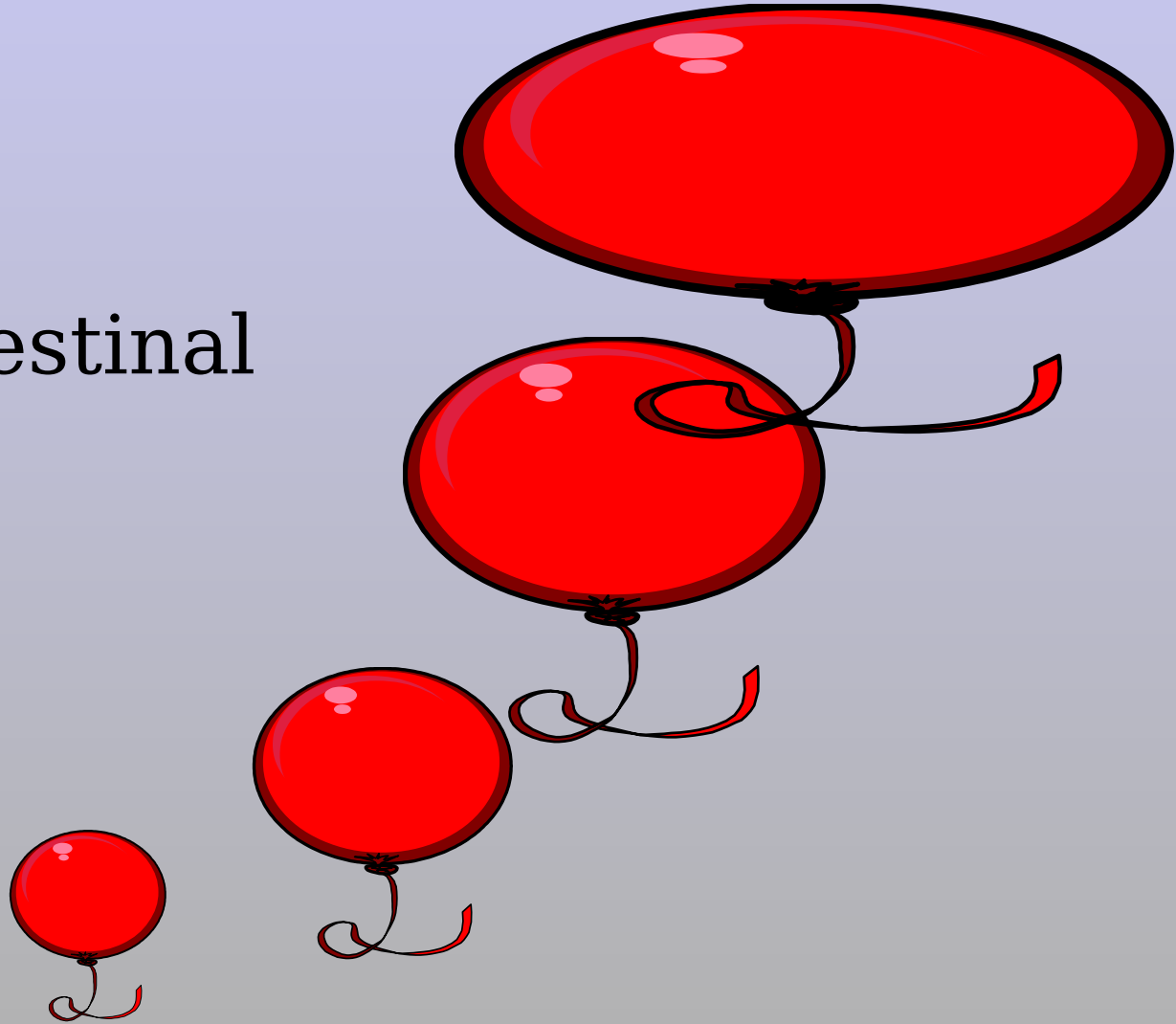
Hypoxia, Trapped and Evolved Gases

Hypoxia

- F-15A, Four Ship, Offensive Counter Air
- MC-130H, High Altitude Airdrop

Trapped Gas

- Ears
- Sinuses
- Gastro-intestinal
- Teeth

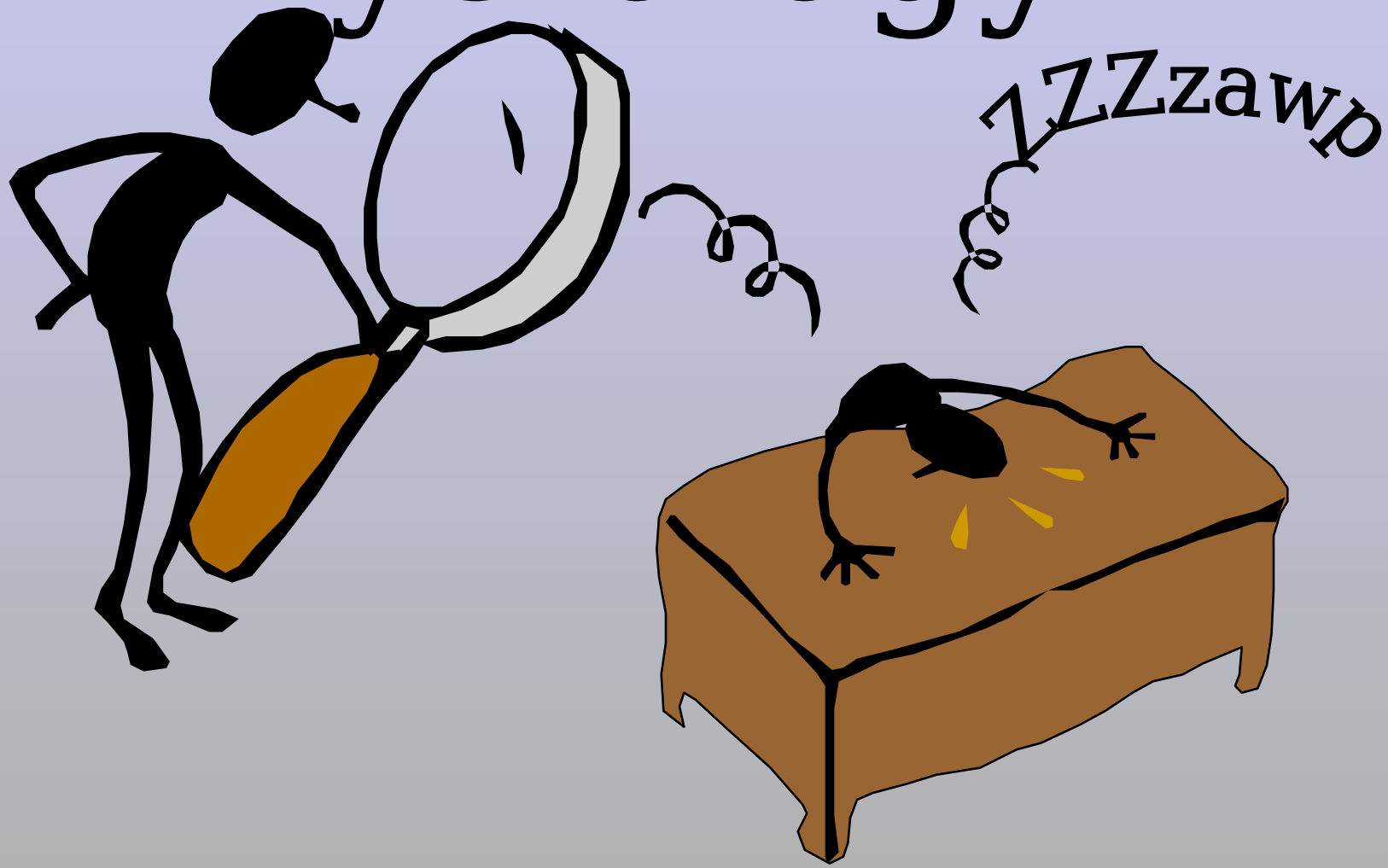


Gastro-intestinal problems

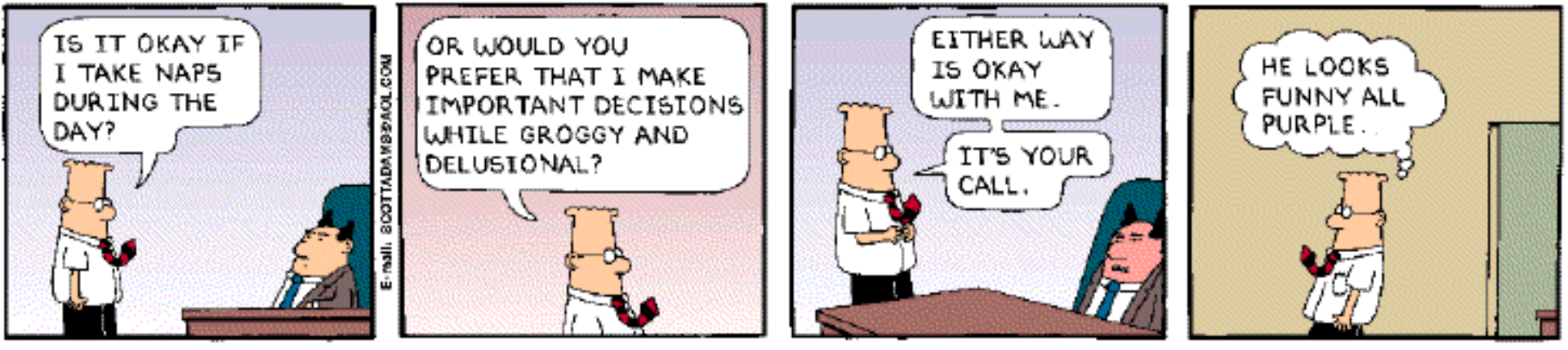
Decompression Sickness

C-17: High Altitude Airdrop test

Sleep Physiology



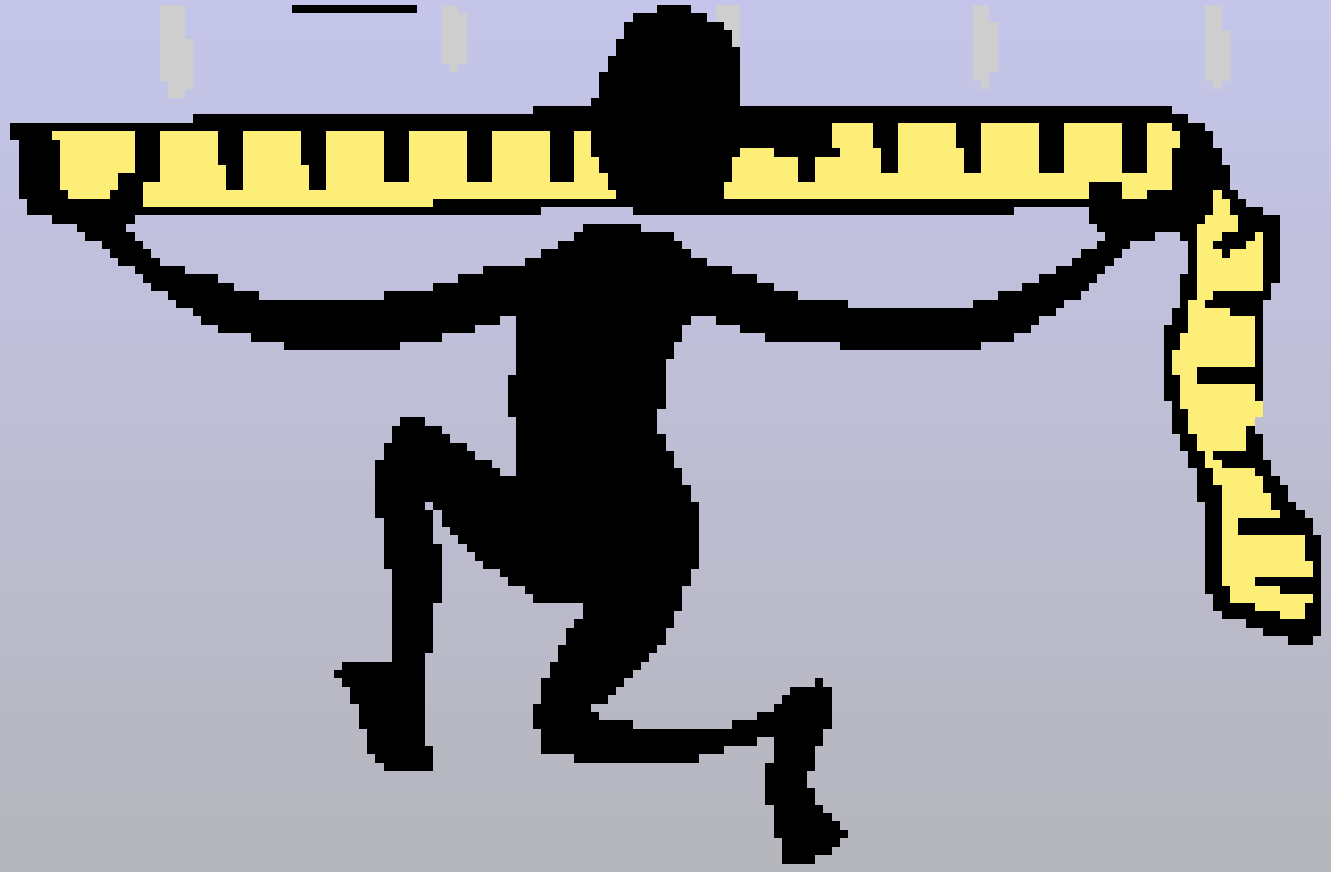
Self-Imposed Stress/Fatigue


IS IT OKAY IF I TAKE NAPS DURING THE DAY?
E-mail: SCOTTADAMS@AOL.COM
OR WOULD YOU PREFER THAT I MAKE IMPORTANT DECISIONS WHILE GROGGY AND DELUSIONAL?
EITHER WAY IS OKAY WITH ME.
IT'S YOUR CALL.
HE LOOKS FUNNY ALL PURPLE.

Flying Schedules and Sleep

- Flying schedules have very large effects on work demand, effort, performance, and fatigue.
- The level of crewmember alertness and performance is governed strongly by the amount and quality of rest acquired before and between periods of work
- There are three major determinants of sleep tendency during a period of intended wakefulness,
    1. Circadian-circasemidian effects,

Sleep Length



In-Class Example: Epworth Sleepiness Scale

- Rate the likelihood that you would doze off during:
  - Sitting and reading
  - Watching TV
  - Sitting inactive in a public place; for example, a theater or meeting
  - As a passenger in a car for an hour without a break
  - Lying down to rest in the afternoon when circumstances permit
  - Sitting and talking to someone
  - Sitting quietly after lunch without alcohol
  - In a car while stopped for a few minutes in traffic

0 = Would *never* doze

1 = *Slight* chance of dozing

2 = *Moderate* chance of dozing

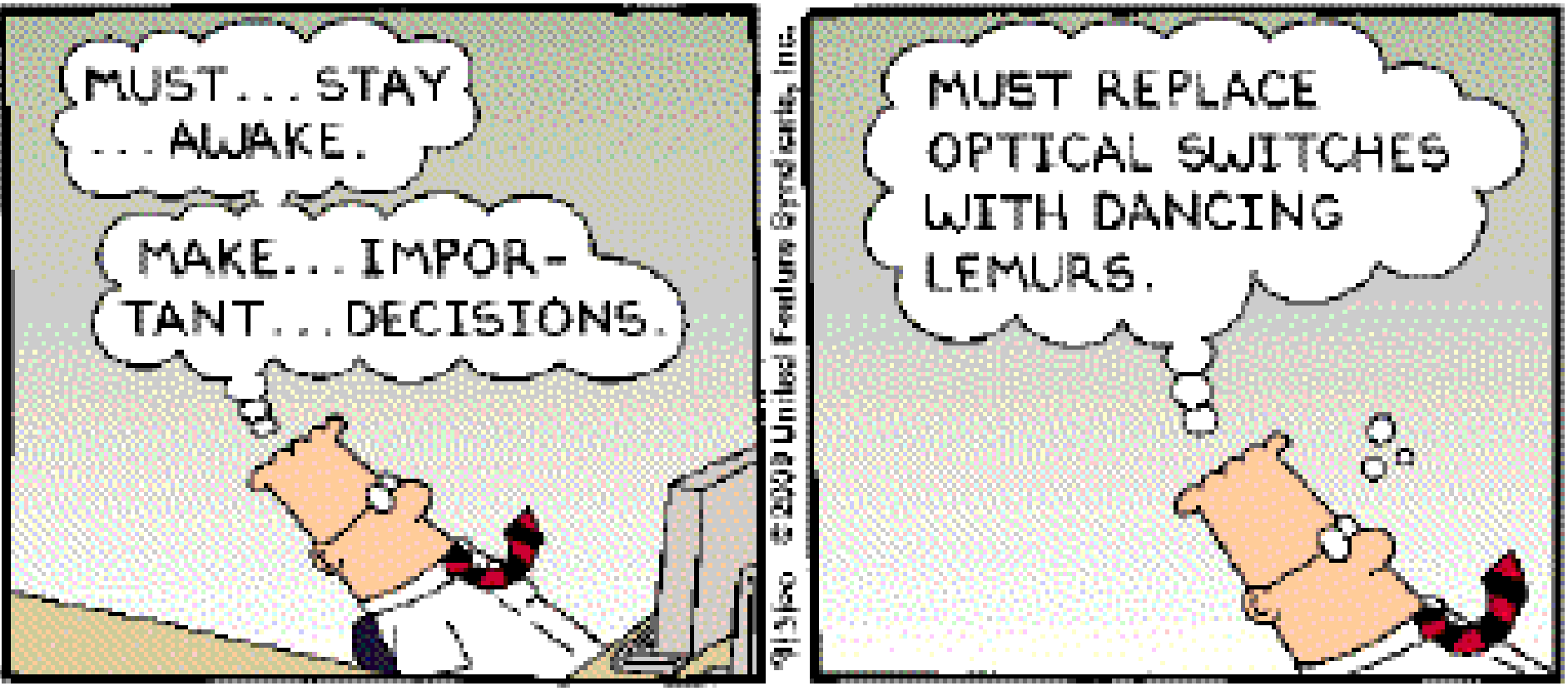
3 = *High* chance of dozing

Epworth Sleepiness Scale (cont)

- if your score is less than 10, then you are doing well. The suggestions provided here may help you fine-tune your sleep hygiene or nutrition
- if your score is 10 to 15, then you have a moderate problem. You need to implement many of the suggestions provided here
- if your score is greater than 15, then you have a serious problem and may even wish to consult a physician in addition to implementing the suggestions provided here

- 32% of U.S. adults who suffer from significant daytime sleepiness scored 10 or more

...51% say sleepiness interferes with the amount of work they do...



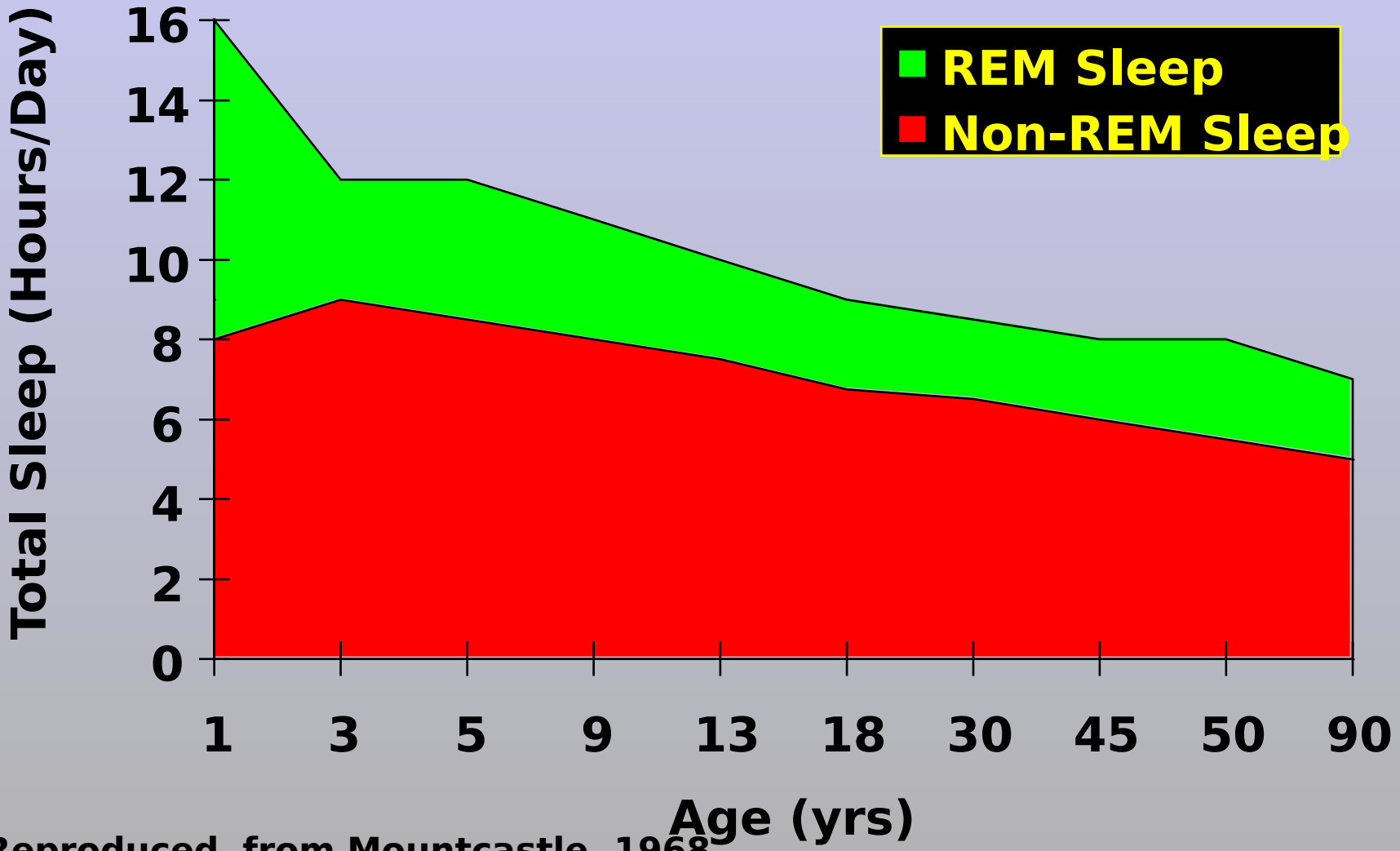
Sleep Physiology

- NREM (non-rapid eye movement) sleep
  - physio & mental activity slowed
  - light sleep (stages 1 & 2)
  - deep sleep (stages 3 & 4)
- REM (rapid eye movement) sleep
  - physio & mental activity increased
  - dreaming (active brain in a paralyzed body)

Sleep Physiology (2)

- Amount and structure of sleep changes over lifetime
  - sleep becomes less deep, more disrupted, and total nocturnal sleep decreases
  - NASA study: daily % sleep loss is 3.5x greater in long-haul crews age 50-60 than in those 20-30
- Quantity vs quality of sleep
  - 8 hr of disrupted sleep can have effects similar to too little sleep
  - After sleep loss, sleep is deeper rather than longer

A Lifetime of Sleep: REM vs Non-REM Time



*Reproduced from Mountcastle, 1968

Sleep Physiology (3)

- Effects of alcohol
  - suppress REM, disrupted sleep
  - interaction with mission imposed sleep loss
- Effects of meds
  - delay sleep onset, disrupt sleep cycles, alter total sleep time, create dependency, carryover effects on waking performance
- Sleep disorders
  - diagnosis/treatment by sleep disorder specialist

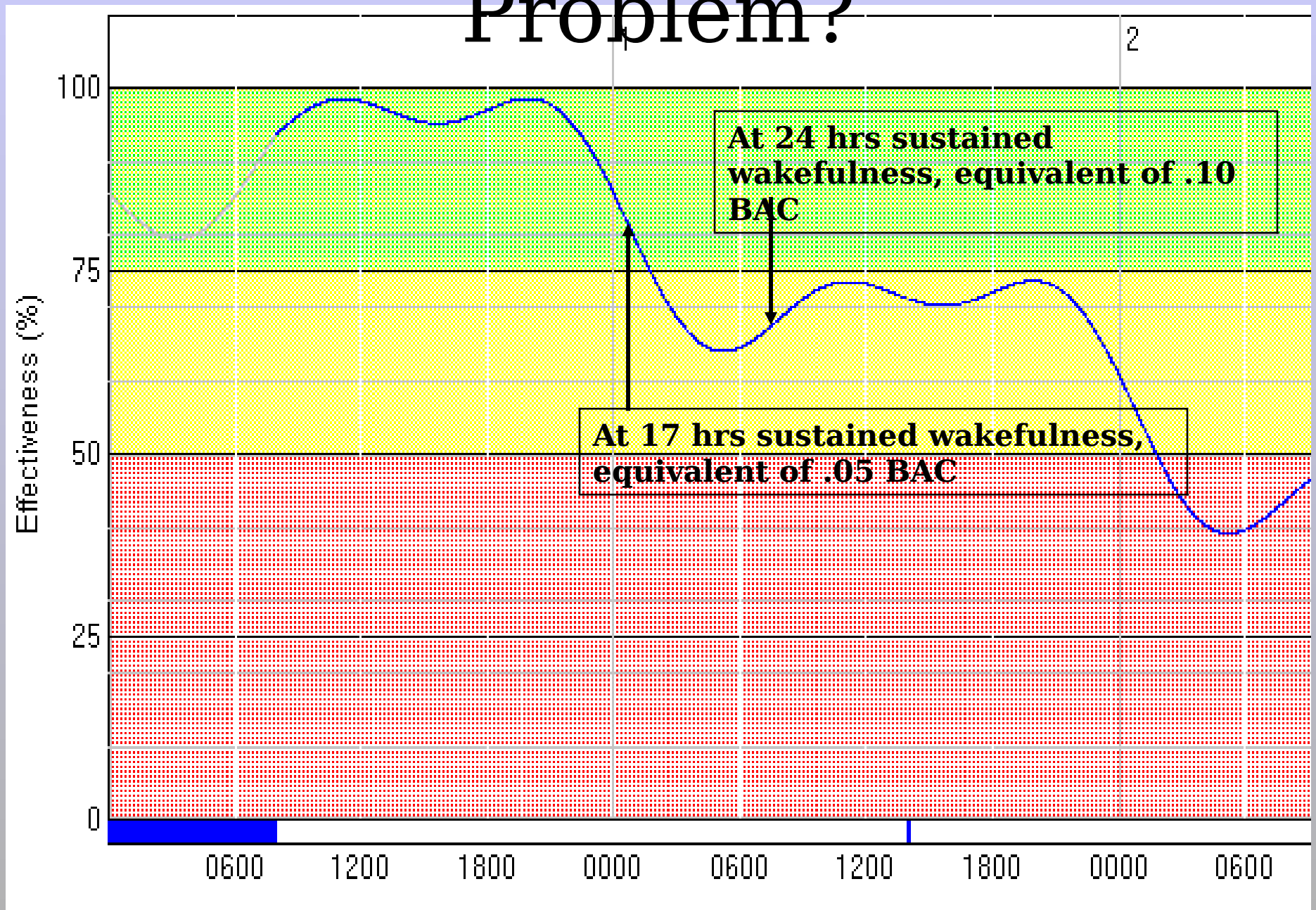
Sleep Physiology (4)

- Effects of environmental factors
  - noise, temperature, light may interfere with good sleep
- Sleep loss is mostly additive and results in cumulative sleep debt

Subjective vs Physiological Sleep and Alertness

- It is difficult to reliably estimate your own sleep and alertness
  - tend to overestimate time required to fall asleep and underestimate total sleep time
    - it may not be as bad as you think
  - tend to report greater alertness than seen in physio measures
    - it may be worse than you think

Is Aircrew Fatigue a Problem?



BIZARRO By Dan Piraro
DO YOU HAVE SOMETHING EVEN LOWER IMPACT THAN THE STAIRMASTER?
HOW ABOUT THE NAPMASTER?
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PIRARO

Cockpit Napping 101

Sleep Inertia 1

- Sleep inertia is the reason for avoiding awakening from deep sleep
- Sleep inertia is somewhat paradoxical in that performance is *worse* after awakening than it was *before sleep*

Sleep Inertia 2

The things that we know about sleep inertia include the following:

- Inertia is greater immediately following deep sleep than immediately following dreaming sleep
- The deeper the deep sleep or the more deep sleep experienced, the greater the inertia and its duration
- Inertia after naps is greatest for naps that occur in the circadian nadir in the pre-dawn hours
- Attention and accuracy are more impaired by sleep inertia than are simple, automatic motor responses
- These effects may be noticeable for up to an hour or more

Sleep Inertia 3

How may an aircrew member deal best with sleep inertia?

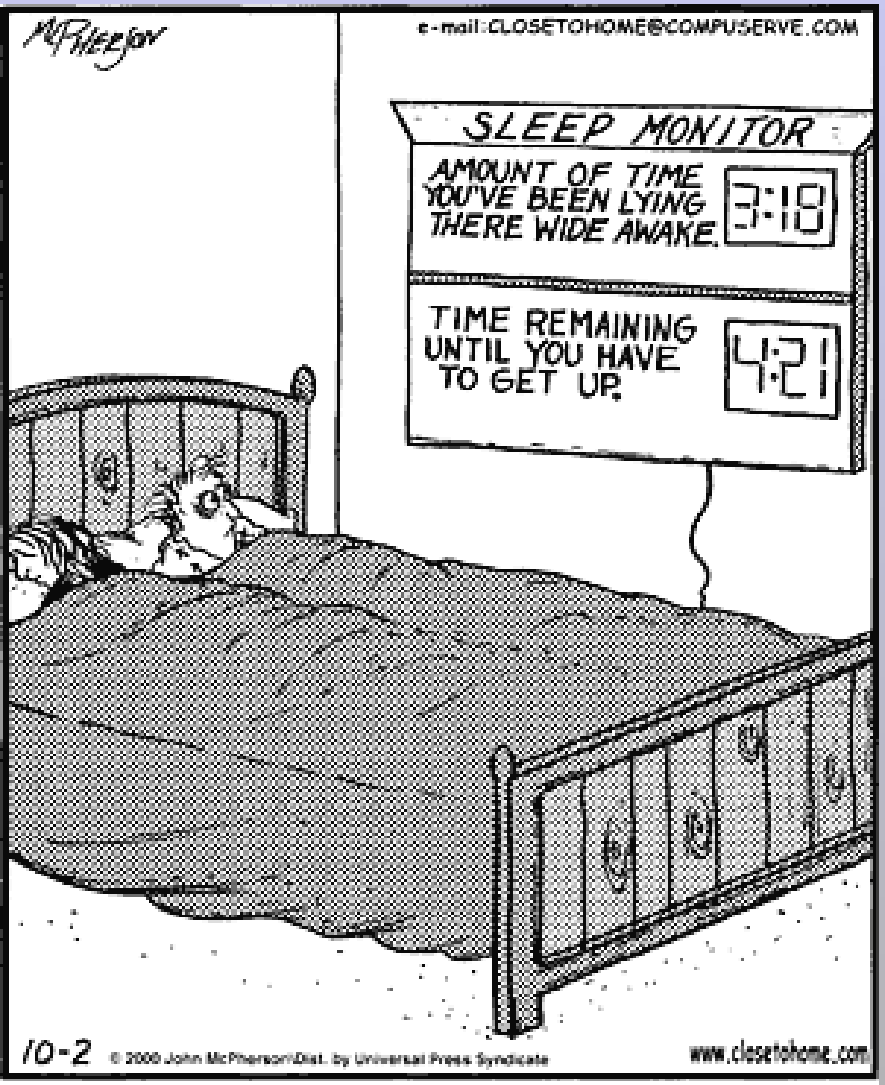
- For the non-sleep-deprived or only mildly sleep-deprived crewmember, sleep inertia will last 5 to 30 minutes
  - Plan to be awake for at least 30 minutes before the task.
- For the crewmember who has missed all or most of a night of sleep, sleep inertia may last
  - .5 hour to 2 hours after a nap of up to 45 minutes, or even 3 hours after a nap of 90 minutes

Sleep Inertia 4

How may an aircrew member deal best with sleep inertia?

- Crewmembers who have missed all or most of a night of sleep, should avoid napping at all during the pre-dawn hours if they must complete a critical task within a couple of hours after the nap
- They will find it very difficult to recover from sleep inertia in that situation

Good Sleep Hygiene



When technology is bad.

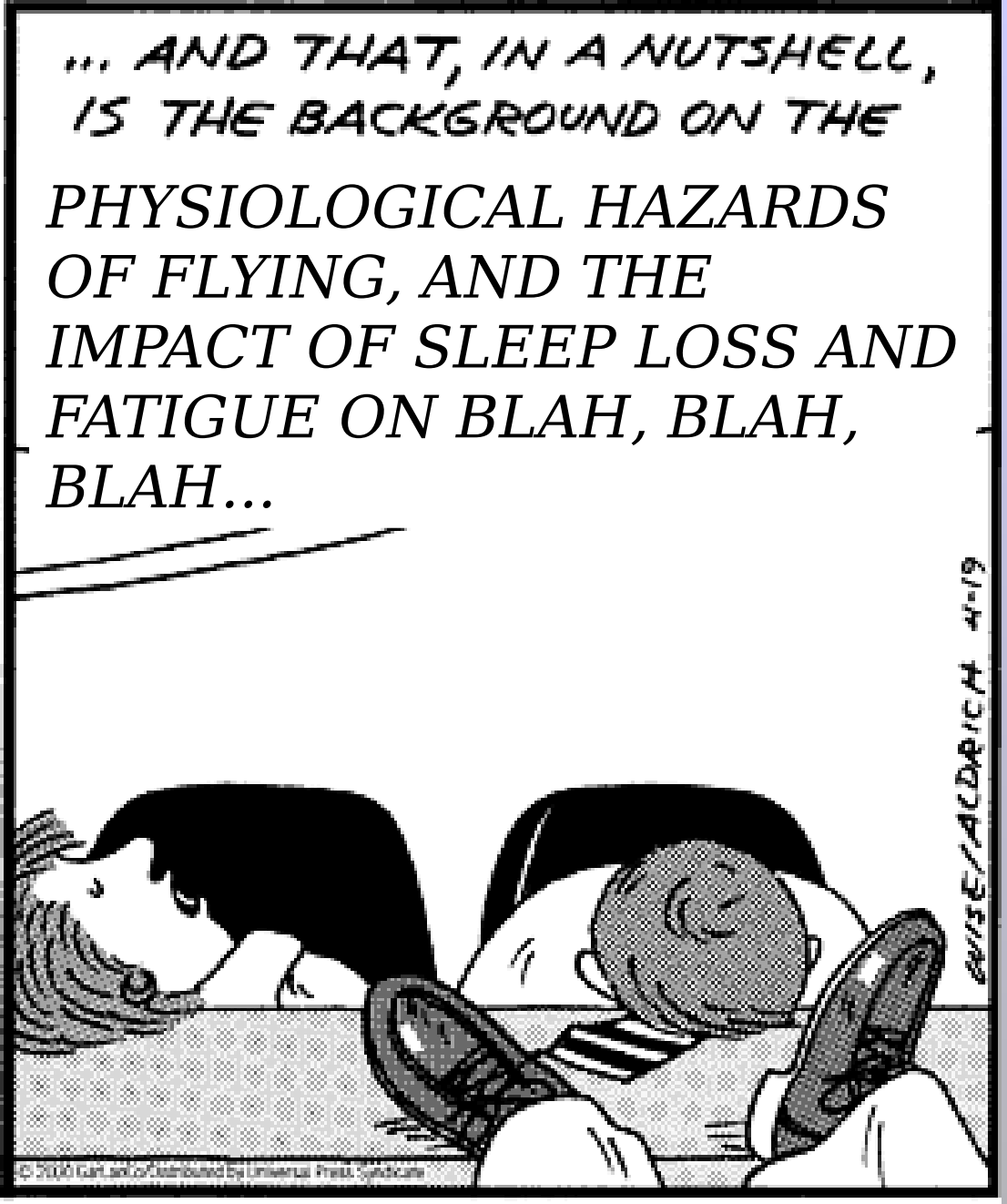
- **Good Sleep Behaviors**
  - Use a bedtime ritual. For example, read a good book to take your mind off the stresses of work. When you feel drowsy, turn off the light.
  - Don’t watch the clock. Hide illuminated clocks from view. If needed, set a couple of alarms and arrange for a wake-up call.
  - Dress appropriately. Use loose-fitting, soft garments that breathe, in the right weight for the temperature of the bedroom

Good Sleep Hygiene (cont)

- **A Good Sleep Environment**
  - Strive for quiet. Low level and consistent sound may be useful. Soft static may help mask unwanted sounds: set the radio between FM stations and turn the volume to low. You may need to use soft earplugs.
  - Strive for darkness. If needed, use a blanket or towel to block a window or the edges of a door. You may need to use an eyeshade.
  - Set the room temperature to 65 degrees F (20 degrees C). Strive for a humidity level of 60-70%.

Modeling Acute Fatigue

- Fatigue Avoidance Scheduling Tool (FAST)
  - developed under AF contract by NTI Inc.
    - original model developed by Dr. Steven Hursh
  - straight-line decrease in pilot performance
  - max perf assumes rest from 2200 to 0600 hrs
    - morning is 98% effectiveness
    - bedtime is 86% eff.
    - 80% eff. at 0330, 60% eff. w/sleep loss
  - you should be concerned about the safety of pilots who are projected to fall below 90%


... AND THAT, IN A NUTSHELL, IS THE BACKGROUND ON THE
PHYSIOLOGICAL HAZARDS OF FLYING, AND THE IMPACT OF SLEEP LOSS AND FATIGUE ON BLAH, BLAH, BLAH...
BLISE/ACADEMY 4-19

You can tell a lot about your speech by the body language of your audience.

QUESTIONS?

- We should all bear one thing in mind when we talk about a troop who rode one in. He called upon the sum of his knowledge and made a judgement. He believed in it so strongly that he knowingly bet his life on it. The fact that he was mistaken in his judgement is a tragedy, not stupidity. Every supervisor and contemporary whoever spoke to him had an opportunity to influence his judgement. So a little bit of all of us goes in with every troop we lose.

Anonymous